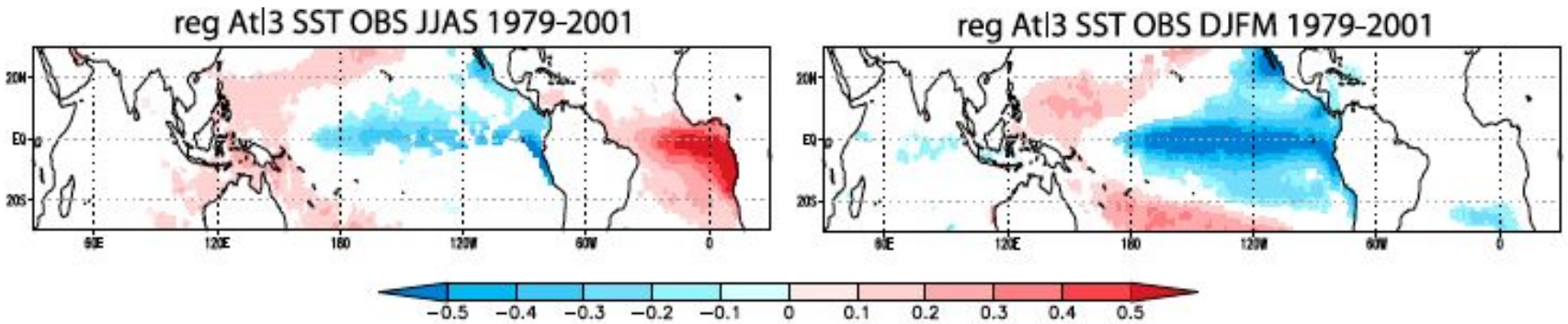
Impact of Equatorial Atlantic Variability on ENSO Predictive Skill

Eleftheria Exarchou[1], Pablo Ortega[1], Belén Rodríguez de Fonseca[2], Teresa Losada[2,3], Irene Polo Sánchez[2], and Chloé Prodhomme[4]

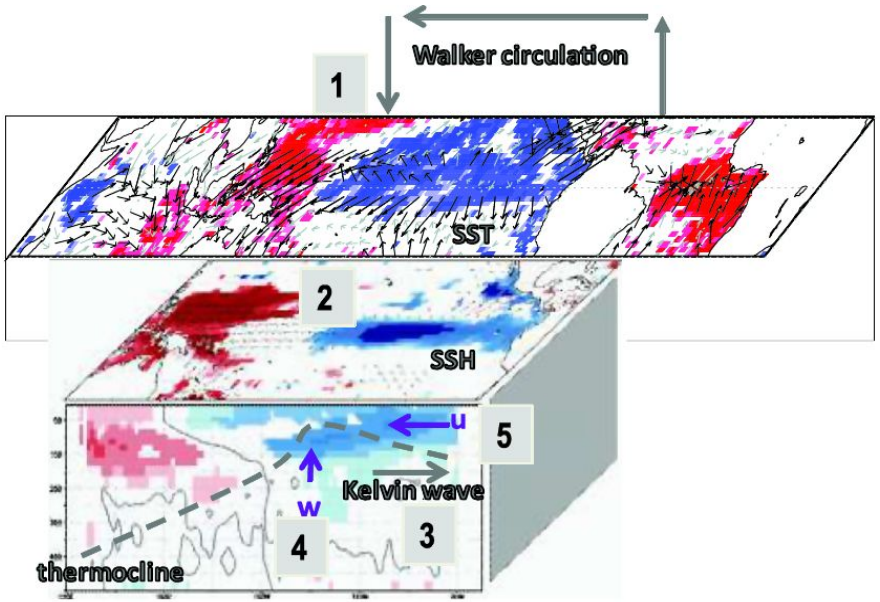
1 1 Barcelona Supercomputing Center (BSC) 2 Universidad Complutense de Madrid (UCM), 3 Instituto de Geociencias, IGEO (CSIC-UCM) 5 CNRM, Meteo-France, CNRS

In observations summer Atlantic Niños (Niñas) favor the development of Pacific Niñas (Niños) the following winter.



Rodríguez-Fonseca, B. et al. (2009)

Tropical Atlantic - Pacific connection



Polo I. et al. (2015)

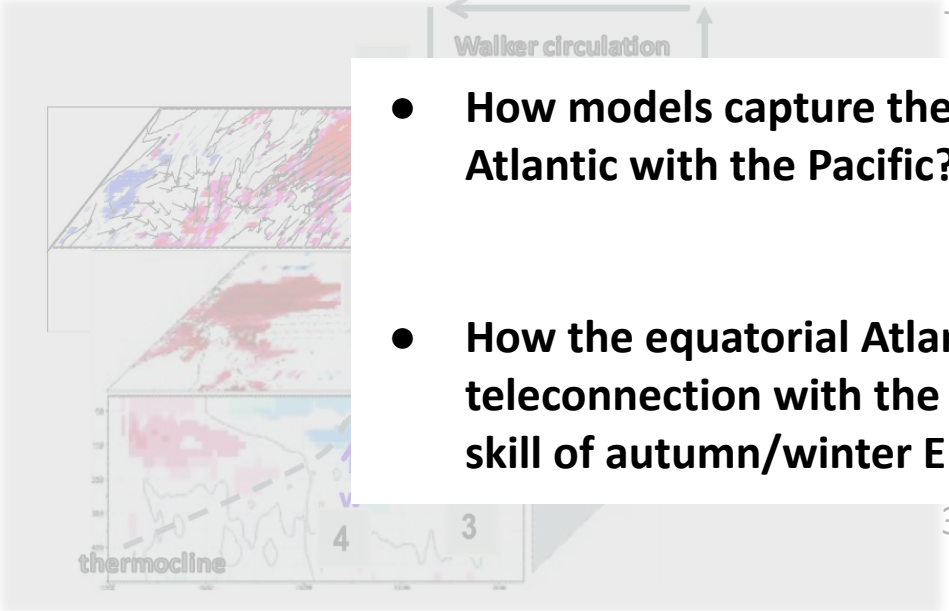
1. Anomalous heating from Atlantic Nino → anomalous convergence in Atlantic → anomalous divergence and subsidence in central/western Pacific

2. Anomalous easterly wind stress in central Pacific → anomalous Ekman upwelling and thermocline shallowing in Central Pacific → piling of surface warm water in the west Pacific

3. The thermocline anomaly propagates eastwards as a Kelvin wave

4. The shallowing thermocline brings cold water to the surface → stronger easterly surface wind anomalies (+ve feeedback)

Tropical Atlantic - Pacific connection



Polo I. et al. (2015)

- **How models capture the teleconnection of equatorial Atlantic with the Pacific?**

- **How the equatorial Atlantic variability and its teleconnection with the Pacific relates to the prediction skill of autumn/winter ENSO?**

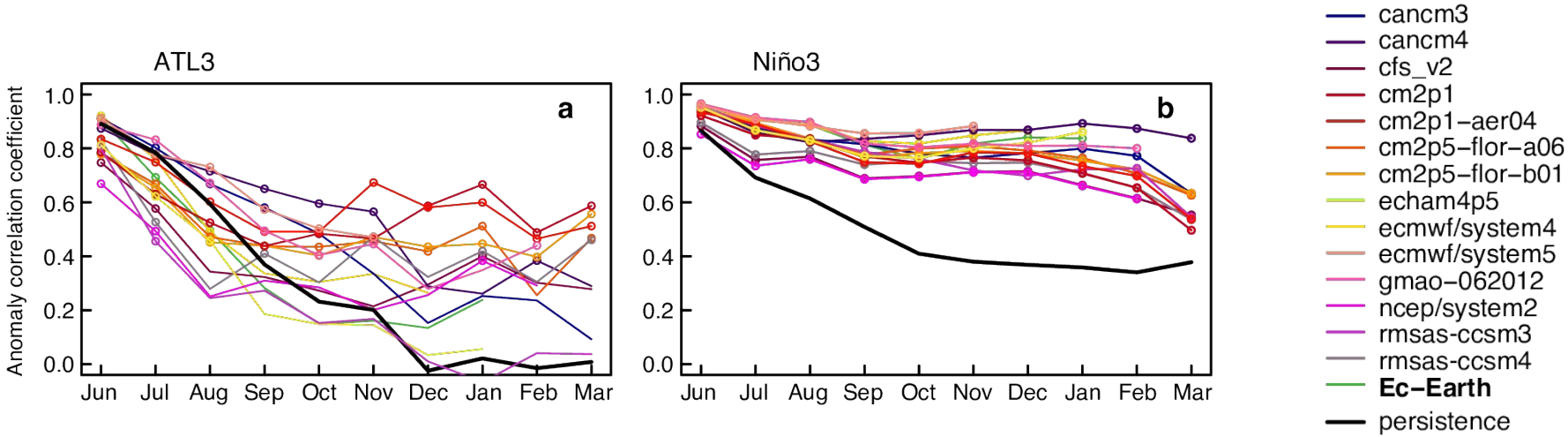
1. Anomalous heating from Atlantic Nino ⟶ anomalous convergence in Atlantic ⟶ ence in

central Pacific
nd
Pacific ⟶
e west Pacific

3. The thermocline anomaly propagates eastwards as a Kelvin wave

4. The shallowing thermocline brings cold water to the surface ⟶ stronger easterly surface wind anomalies (+ve feeedback)

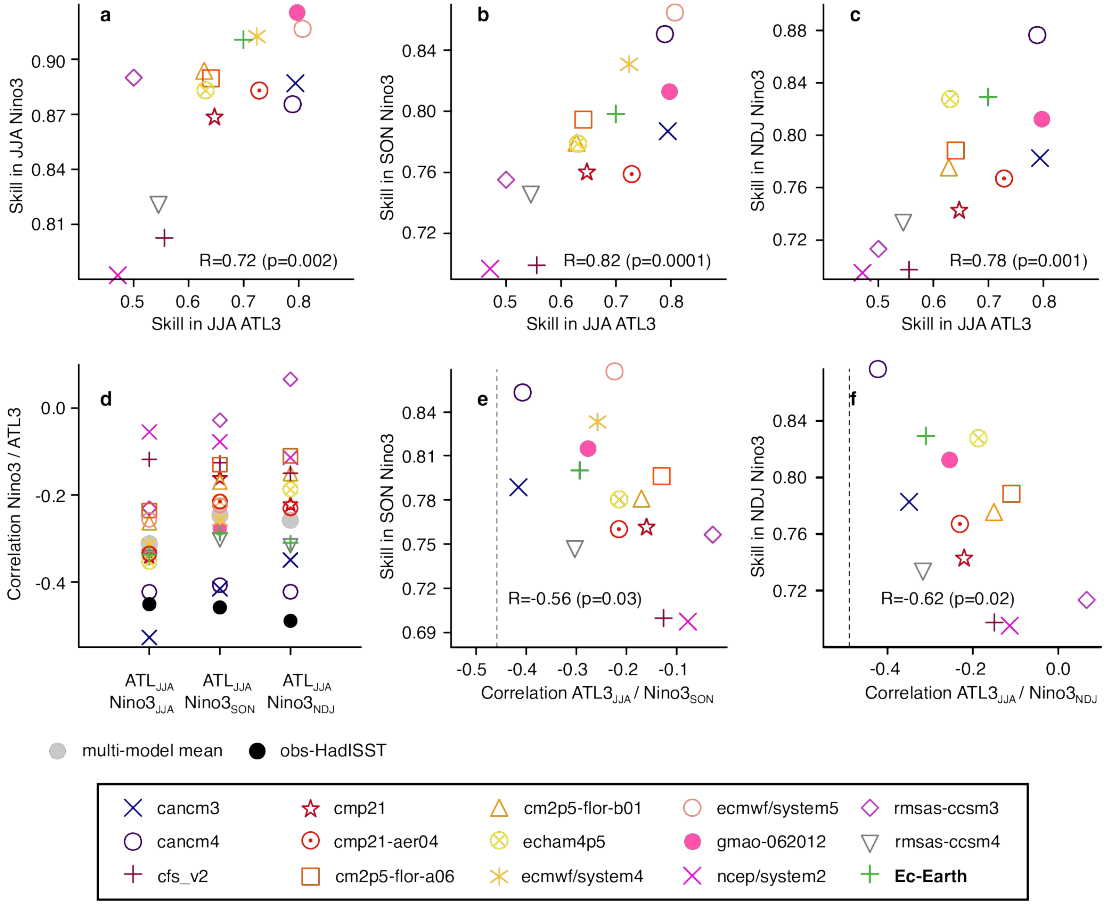
Multi-model ensemble study (NMME[+])



ATL3 has comparatively lower skill and a large inter-model spread. Niño3 is highly predictable, but with an inter-model spread that increases with forecast time.

[+]Kirtman, B. P. et al. (2014).

Multi-model ensemble study (NMME[+])



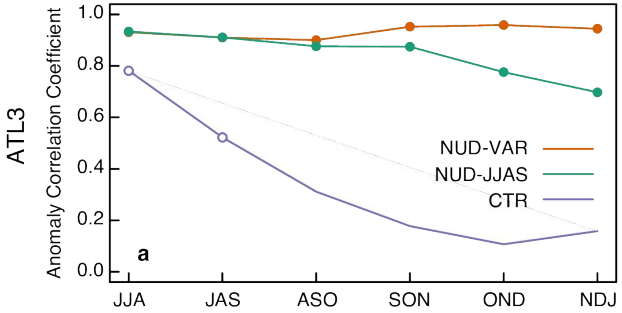
SON/NDJ Niño3 skill is linearly related with both ATL3 JJA skill and the strength of the teleconnection. The higher the ENSO skill is, the stronger (and therefore more realistic) the teleconnection tends to be.

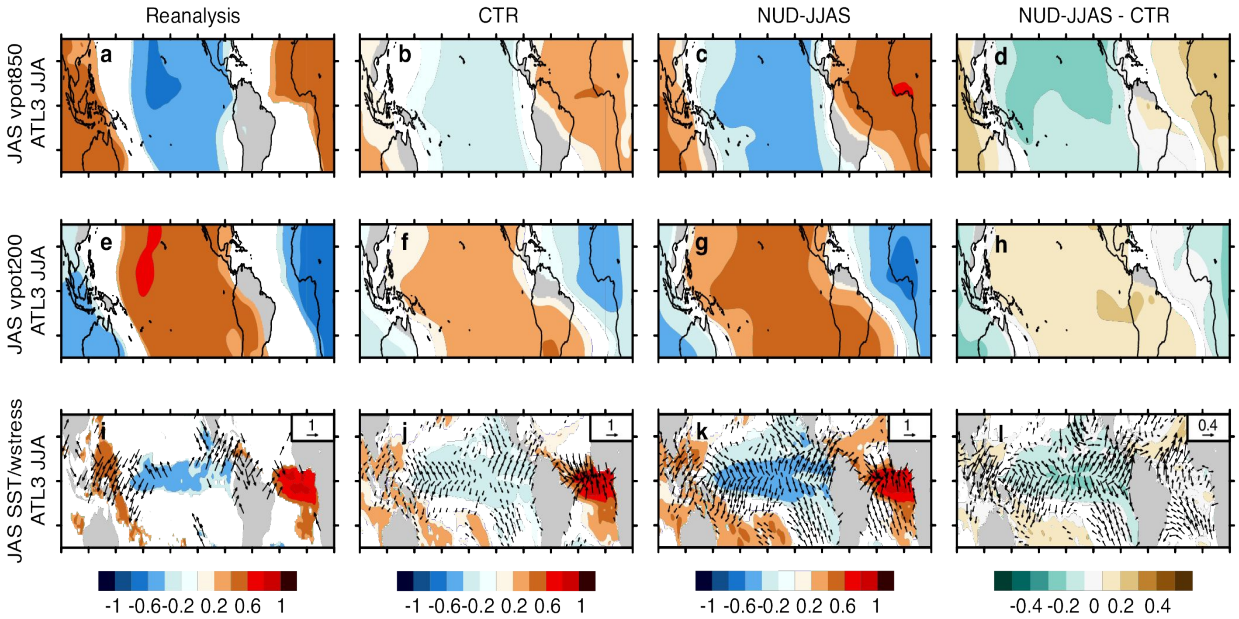
[+]Kirtman, B. P. et al. (2014).

Sensitivity study (EC-Earth)

1981-2018, 15 members, 8 months long, June initialization

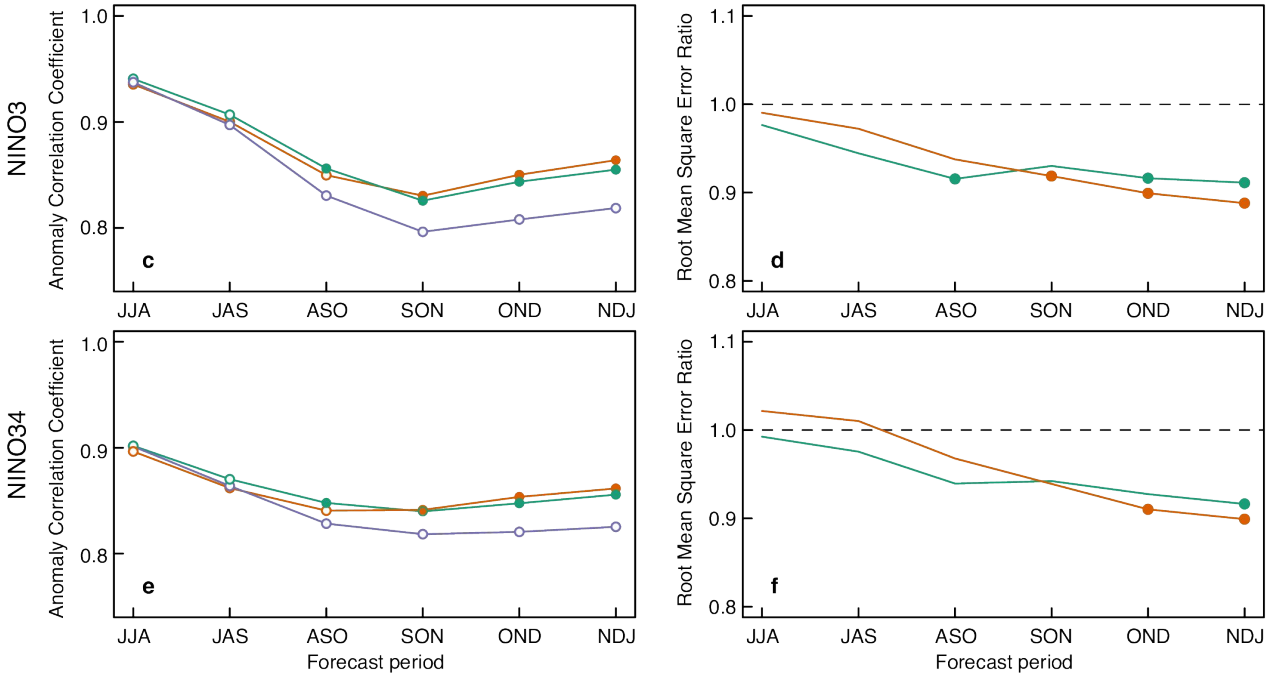
1. **CTR** baseline prediction.
2. **NUD-VAR** SST restoring in the equatorial Atlantic (5° S-5° N).
3. **NUD-JJAS**, as #2 but SST restoring only in June-September.





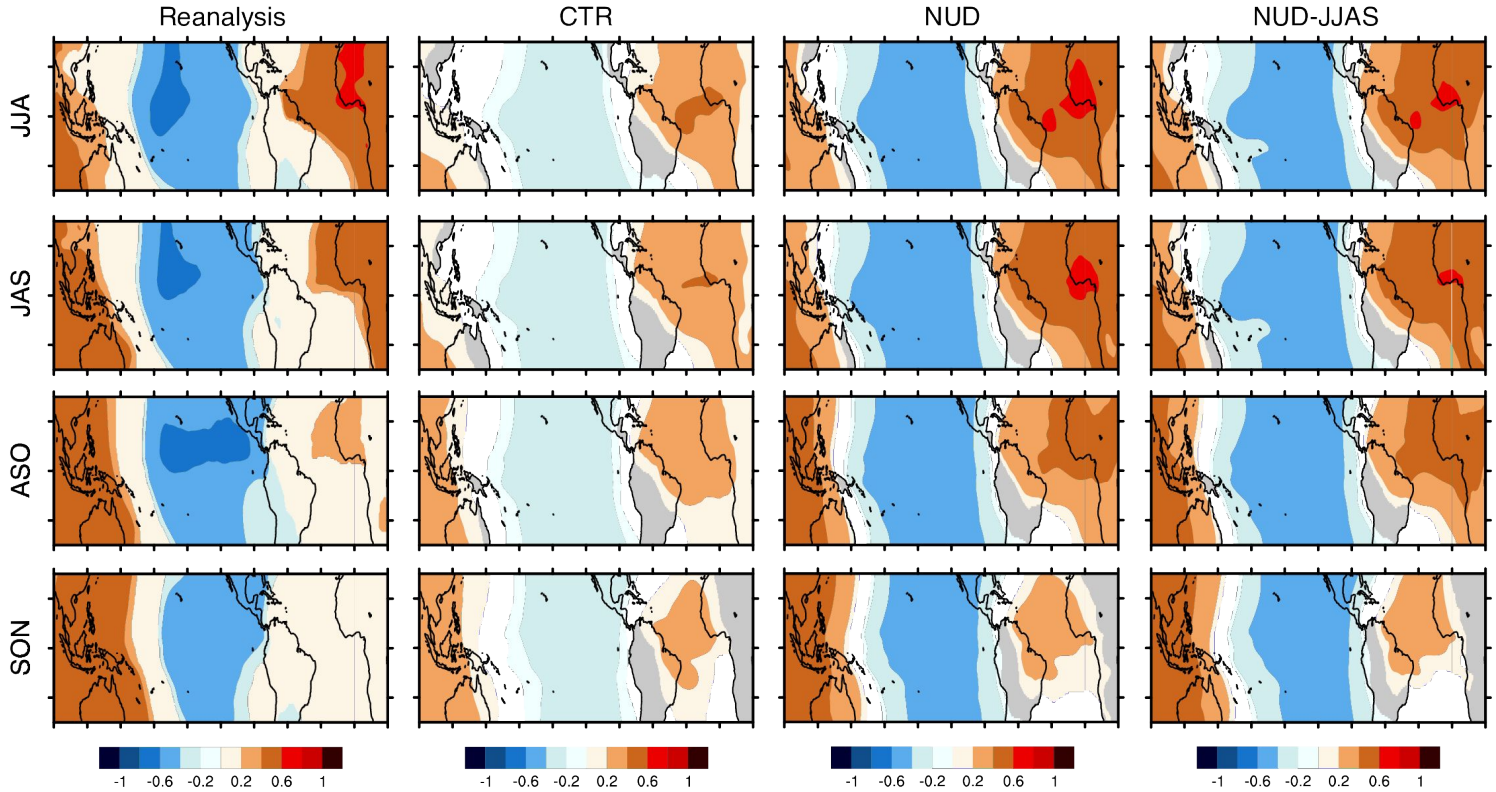
Lagged correlations between the JJA ATL3 SST index and SST/velocity potential at 200/850 hPa show that **NUD-VAR & NUD-JJAS show improvement in the representation of the teleconnection** compared to CTR

Sensitivity study (EC-Earth)



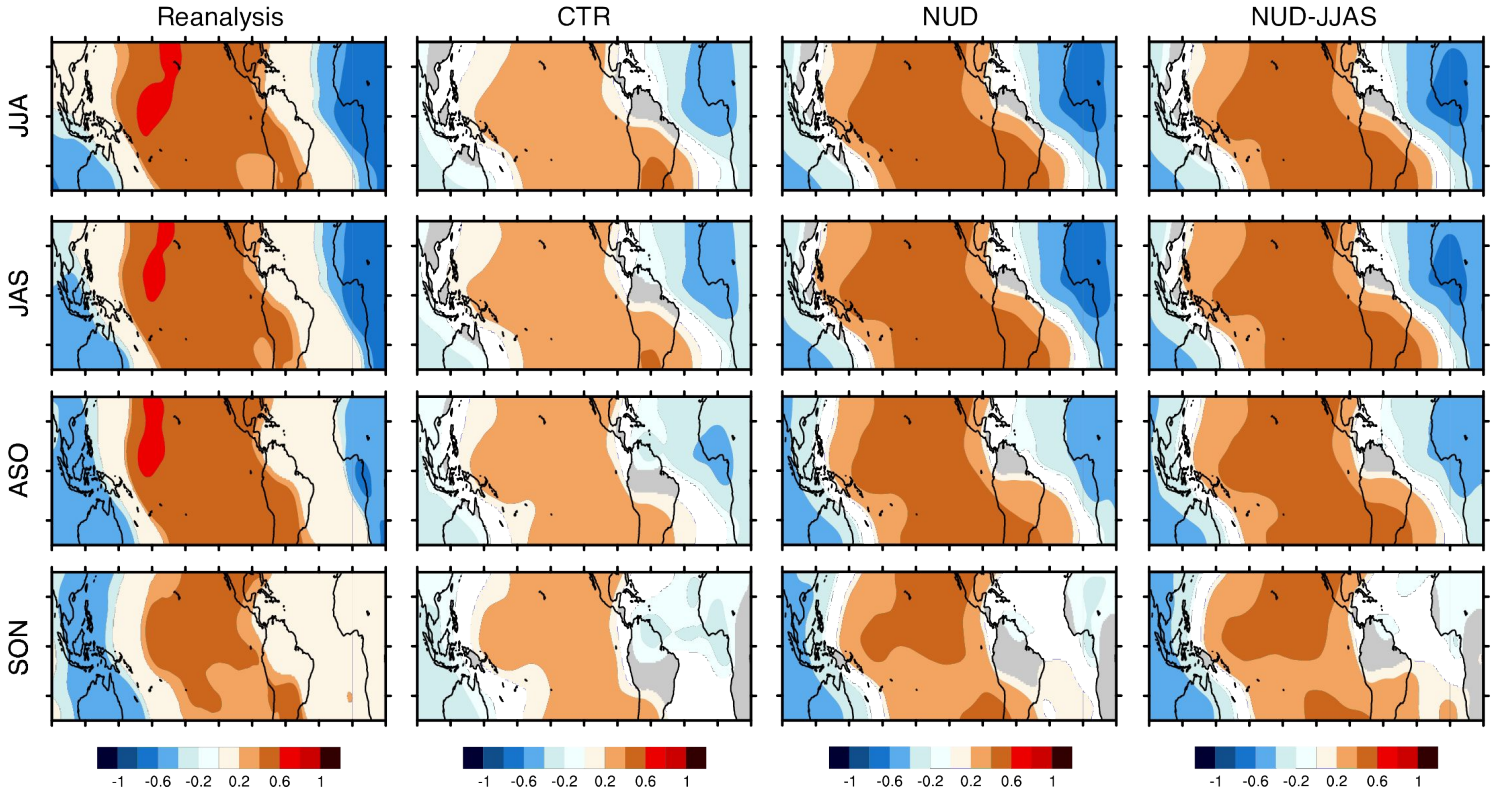
NUD-VAR & NUD-JJAS show **significant improvements in skill** (ACC) and RMSE in Niño3/Niño3.4 in autumn and winter.

Sensitivity study (EC-Earth)



Correlation pattern between JJA ATL3 index and the velocity potential at 850 hPa

Sensitivity study (EC-Earth)

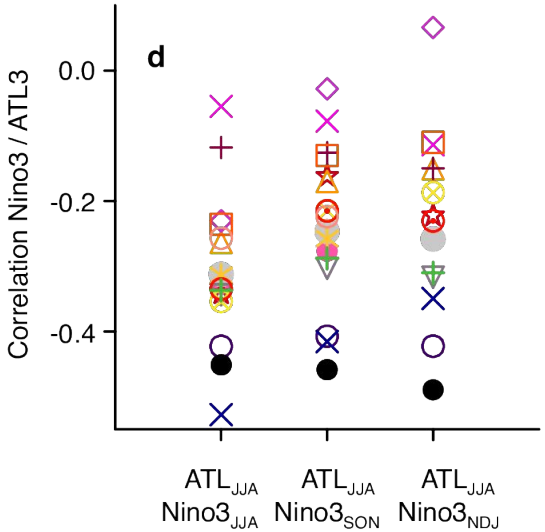


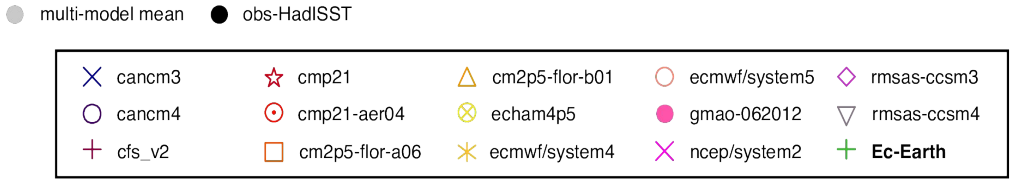
Correlation pattern between JJA ATL3 index and the velocity potential at 200 hPa

Summary

- **How models capture the teleconnection of equatorial Atlantic with the Pacific?**

All models underestimate the teleconnection strength (i.e. the magnitude of the negative correlation).
In some models the correlation is close to zero.





Summary

- **How the equatorial Atlantic variability and its teleconnection with the Pacific relates to the prediction skill of autumn/winter ENSO?**

  An improved representation of equatorial Atlantic variability in summer and its teleconnection with the Pacific relates to enhanced skill of autumn/winter ENSO.

  The sensitivity study shows that correcting the SST in equatorial Atlantic improves forecast skill in the autumn/winter Tropical Pacific.

  The equatorial Atlantic is affected by long-standing model biases that can deteriorate its prediction skill. Reducing these biases offers the potential to increase the prediction skill of ENSO.

👉 Exarchou, E., P. Ortega, B. Rodríguez-Fonseca, T. Losada, I. Polo and C. Prodhomme (2021). Impact of equatorial Atlantic variability on ENSO predictive skill. Nat Communications, volume 12, 1612 (2021)

Abstract

El Niño–Southern Oscillation (ENSO) is a key mode of climate variability with worldwide climate impacts. Recent studies have highlighted the impact of other tropical oceans on its variability. In particular, observations have demonstrated that summer Atlantic Niños (Niñas) favor the development of Pacific Niñas (Niños) the following winter, but it is unclear how well climate models capture this teleconnection and its role in defining the seasonal predictive skill of ENSO. Here we use, for the first time, an ensemble of seasonal forecast systems to demonstrate that a better representation of equatorial Atlantic variability in summer and its lagged teleconnection mechanism with the Pacific relates to enhanced predictive capacity of autumn/winter ENSO. An additional sensitivity study further shows that correcting SST variability in equatorial Atlantic improves different aspects of forecast skill in the Tropical Pacific, boosting ENSO skill. This study thus emphasizes that new efforts to improve the representation of equatorial Atlantic variability, a region with long standing systematic model biases, can foster predictive skill in the region, the Tropical Pacific and beyond, through the global impacts of ENSO.

👉 Exarchou, E., P. Ortega, B. Rodríguez-Fonseca, T. Losada, I. Polo and C. Prodhomme (2021). Impact of equatorial Atlantic variability on ENSO predictive skill. Nat Communications, volume 12, 1612 (2021)